

S/2-31
155102
P-5

N93-29120

INDIGENOUS LUNAR CONSTRUCTION MATERIALS

Wayne P. Rogers and Stein Sture

The utilization of local resources for the construction and operation of a lunar base can significantly reduce the cost of transporting materials and supplies from Earth. This study investigates the feasibility of processing lunar regolith to form construction materials and structural components. A preliminary review of potential processing methods such as sintering, hot-pressing, liquification, and cast basalt techniques, has been completed.

The processing method proposed in this study is a variation on the cast basalt technique. It involves liquification of the regolith at 1200-1300°C, casting the liquid into a form, and controlled cooling. While the process temperature is higher than that for sintering or hot-pressing (1000-1100°C), this method is expected to yield a true engineering material with low variability in properties, high strength, and the potential to form large structural components.

A scenario for this processing method has been integrated with a design for a representative lunar base structure and potential construction techniques. The lunar shelter design is for a modular, segmented, pressurized, hemispherical dome which could serve as habitation and laboratory space. Based on this design, we have made estimates of requirements for power, processing equipment, and construction equipment. This proposed combination of material processing method, structural design, and sup-

port requirements will help to establish the feasibility of lunar base construction using indigenous materials.

Future work will refine the steps of the processing method. Specific areas where more information is needed are: furnace characteristics in vacuum; heat transfer during liquification; viscosity, pouring and forming behavior of molten regolith; design of high temperature forms; heat transfer during cooling; recrystallization of basalt; and refinement of estimates of elastic moduli, compressive and tensile strength, thermal expansion coefficient, thermal conductivity, and heat capacity.

The preliminary design of the lunar shelter showed us that joining is a critical technology needed for building a structure from large segments. The problem of joining is important to the design of any structure that is not completely prefabricated. It is especially important when the structure is subjected to tensile loading by an internal pressure. For a lunar shelter constructed from large segments the joints between these large segments must be strong, and they must permit automated construction. With a cast basalt building material which is brittle, there is the additional problem of connecting the joint with the material and avoiding stress concentration that would cause failure. Thus, a well-defined project which we intend to pursue during this coming year is the design of joints for cast basalt structural elements.

CAST MOLTEN REGOLITH

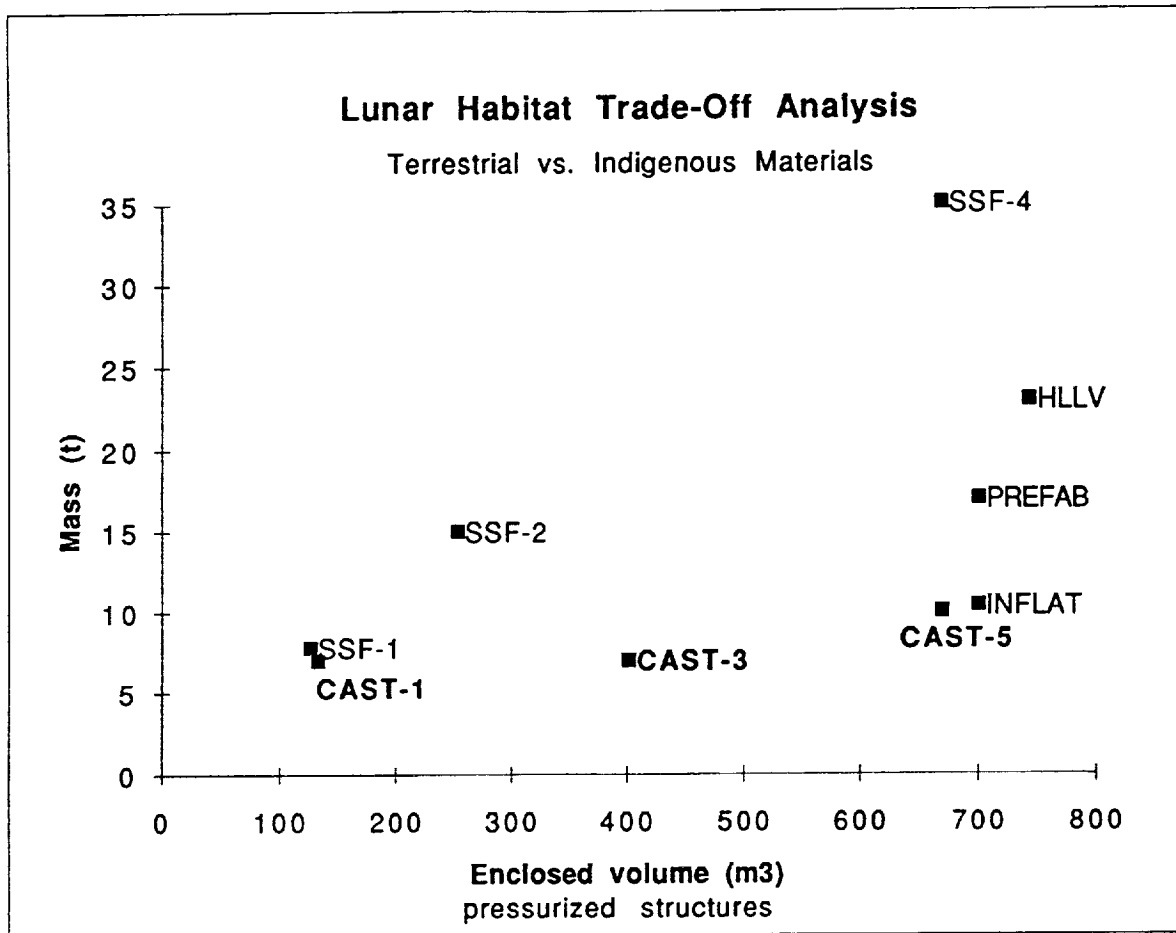
Key Data

- Power: 100 kW
- Furnace efficiency: 90%
- Furnace capacity: 3.6 m³
- Furnace weight: 3 tons
- Melt time: 24 hrs
- Regolith mass: 6 tons
- Structural element size: 2 m³
- Form weight (1 inch thick graphite): 1 ton

Fig 12.1 Key data for cast molten regolith

	Cast Basalt	Concrete	Iron
Ultimate tensile strength (MPa)	36	6	367
Compressive strength (MPa)	550	76	510
Young's modulus (GPa)	110	21	196
Thermal expansion (/C)	7.8×10^{-7}	1.19×10^{-7}	1.2×10^{-5}
Density (g/cm ³)	2.9	2.4	7.8

Fig 12.2 Physical properties of basalt, concrete and iron



Abbreviation	Definition	Number of Airlocks	Description
SSF-1	Space Station Freedom Module	1	Cylinder: 4.5m diam. x 8m
CAST-1	1 cast basalt dome	1	Hemisphere: 8m diam.
SSF-2	2 SSF modules	2	
SSF-4	4 SSF modules	2	
INFLAT.	1 inflatable sphere	1	Sphere: includes support eqt.
PREFAB.	module requires assembly	1	Cylinder: 10.4m diam. x 8.2m
HLLV	heavy lift launch vehicle mod.	1	Cylinder: 7.6m diam. x 8.2m
CAST-5	5 cast basalt domes	2	
CAST-3	3 cast basalt domes	1	

Fig 12.3 Lunar habitat trade-off analysis for terrestrial vs. indigenous materials

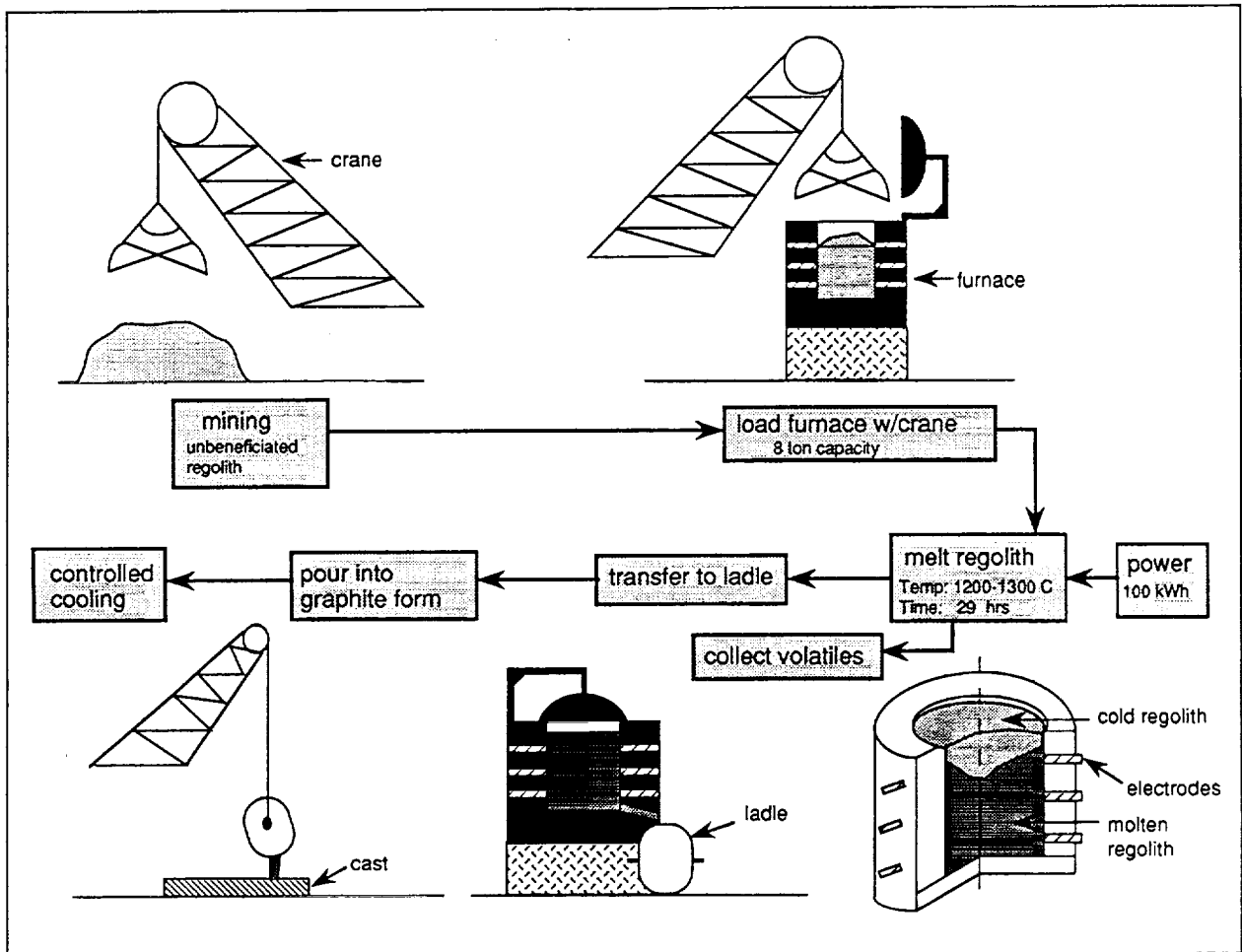


Fig 12.4 Cast molten regolith processing

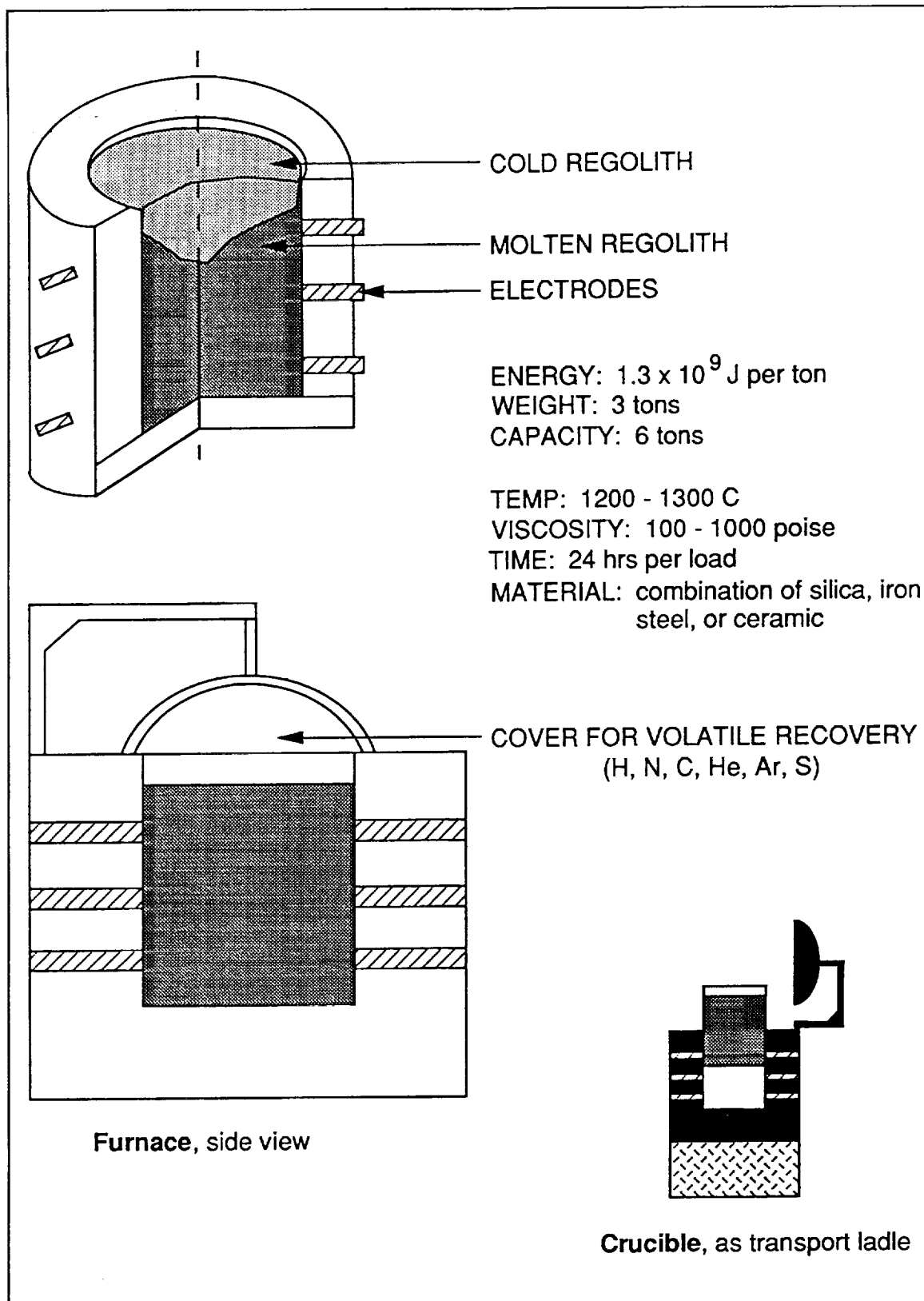


Fig 12.5 Lunar furnace concept